AUSTRALIAN SOCIETY FOR LIMNOLOGY

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LIMNOLOGY NEWSLETTER

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The Australian Society for Limnology is an association of over 400 people with professional or amateur interests related to Australian inland waters Since its inception in 1961 the Society has played an important role in fostering limnological work in this country. The ASL promotes liason between limnologists in academic, private and governmental institutions and has a vested interest in the conservation of aquatic and related resources. Annual conferences are held near centres of limnological interest, and the programme includes scientific sessions, field excursions and social activities.

The ASL produces a newsletter with notes on activities, articles of general interest, book reviews and conference announcements; a Bulletin of original scientific papers and occasional Special Publications. A further publication is the Directory of Australian Limnologists.

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Deadline for Next Edition 20 December

EDITORIAL-TERRORIST TACTICS IN TAXONOMY

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Since recent events in Australian herpetology threaten the stability of all biological nomenclature it is imperative that the whole biological community be aware of what is happening and work towards control of the situation. As mentioned later entomology may be next to be affected.

Our system of classification and nomenclature of animals is a rather fragile and dynamic one, continually growing and evolving to accommodate new taxa and ideas. The protocol of priority of publication of taxonomic names gives much greater weight to the published word in taxomony than in other disciplines (where outrageous work can be simply ignored or dismissed). It follows then that there must be some rational control on what gets into print if any semblance of stability is to be preserved. Several such controls normally exist:

(i) The International Code of Zoological Nomenclature

This is the Code of procedure which binds all taxonomists. It consists of mandatory Rules (Articles) and non-compulsory Recommendations. The Rules alone are not very strict, and this is done purposefully to preserve the validity of the actions of well-meaning authors writing in past years when taxonomic procedures were not well defined. Modern authors would be ethically expected to comply with both Rules and Recommendations.

(ii) Editorial Policy

Most journals maintain high editorial standards outlined in their "Guide to Authors". These generally include some guidelines for taxonomic procedure.

(iii) Refereeing

A cornerstone of modern scientific publication is the system of MS review where specialists in the field are allowed to assess MSS under consideration for publication.

(iv) Printing Costs

These have an inhibitory effect on authors who may wish to resort to private publication of MSS unacceptable to refereed journals. However, as modern printing costs fall this factor becomes less of an impediment to "rogue" authors.

To the dismay of herpetologists around the world two large, privately-printed, unrefereed papers have recently appeared (1984 and 1985), both co-authored by R.W. Wells and C.R. Wellington. These papers make a mockery of the Code's Rules and ignore its Recommendations. Both purport to revise the entire Australian reptile fauna adding no less than 470 species and 107 genera to the previously accepted fauna. Most names are introduced without diagnoses; many are erected on information in other people's work. No keys or illustrations are included and rarely are new taxa differentiated from related taxa. Considering the normal checks, mentioned above, against the issue of such publications one may very well ask how these have come into being. The tale is worth telling ...

Several years ago a group of Sydney herpetologists formed the Australian Herpetologists League for the purpose of starting a periodical called the Australian Journal of Herpetology. By virtue of the enrolment of its Editor, Richard Wells, in 1st year of a B.Sc at University of New England the periodical was able to use a University address. The first two issues of Aust. J. Herp. appeared in 1981 and contained a broad spectrum of conventional herpetology papers from both amateur and professional authors. Individuals and libraries from Australia and overseas subscribed giving it a financial base. An Editorial Board of three professional herpetologists, including Professor Heatwole from UNE, was formed to arrange reviewing of MSS before transmission to Editor Wells. Wells failed to complete his 1st year B.SC. and moved to Sydney, though continuing to use a UNE Post Box for his address. The journal failed to appear for two years though various processed MSS were sent to Wells. Then without warning in 1984 an enlarged 56 pp issue of Aust. J. Herp. appeared completely occupied by a paper entitled "A Synopsis of the Class Reptilia in Australia" authored by R. Wells and C.R. Wellington. It comprised a crude treatment of the entire reptile fauna with 33 new genera, 8 genera raised from synonymy, 14 new species and 200 names raised to species rank or resurrected from synonymy. Instead of the Australian Herpetologists League, the issue was copyrighted to Australian Biological Services, an entity apparently under the sole control of Wells and Wellington, cited respectively as Managing Editor and Advertising Sales Manager. The Editorial Board resigned in protest at the appearance of this unrefereed paper. None of the MSS processed by the Board have ever been published though information from at least one of them was used in Wells and Wellington's own paper. Requests to Wells for return of some of these MSS by their authors have been ignored. A unanimous vote at the AGM of the Australian Society of Herpetologists last year favoured seeking suppression of Wells and Wellington's (hereafter "W&W") paper by the International Commission; however it is clear that this will be no easy goal. Three Letters to the Editor in the latest issue of the international Herp. Review 16(1): 4-7, by the resigned Editorial Board and Carl Gans, an eminent herpetologist, expose the actions of W&W and appeal for non-use of their nomenclature.

Not to be deterred, W&W have just circulated a 2nd purported publication entitled "A Classification of the Amphibia and Reptilia of Australia". This runs to 98 pp. and treats the frogs in the same manner as the first paper, as well as "re-revising" the reptiles. It describes 146 new species and erects 110 more from synonymy; it describes no less than 57 new genera and raises 9 more from synonymy. A further step is the designation of lectotypes for 108 species. The status of this recent issue is unclear. Their first opus appeared in the properly-printed format of previous issues of Aust. J. Herp. This second one is marked Aust. J. Herp. Suppl. Ser. No. 1 and it bears the inscription "Published 1 March, 1985", but the only copies so far sighted are spiral bound photocopies of computer printout. (See footnote). Requests for original copies have been unanswered by its authors. The address of Wells in this issue has changed to a mythical "Australian Zoological Museum" at a PO Box in Katoomba. Wellington's address is given at nearby Blaxland High School where he teaches.

A curious feature of their 2nd paper appears in its "References" where more than 500 purported papers by W&W are cited as having been published since 1983 in Australian Herpetologist. These are systematically listed by titles and page numbers, many approaching 100 pp. in length. Also a 10 volume work titled "The Herpetology of Australia" by Wells and Magnus Peterson is listed as "in press" with Australian Biological Services. Peterson is known to many museum entomologists for his interest in jewel beetles and dragonflies. The bizarre aspect of these listed publications is that they do not exist; Australian Herpetologist is a "phantom" periodical, unknown to libraries.

Throughout both publications a contrived patina of respectability is presented by effusive acknowledgement to other Australian herpetologists for assistance, and by the ostentatious bestowal of patronymic species names on everyone from the Prime Minister down - even Darth Vader scores a genus! Many of those acknowledged joined the motion seeking supression of W&W's work.

Clearly much effort by W&W went into their contentious MSS, for both MSS methodically deal with the whole Australian reptile fauna, the 2nd also treating all Amphibia. One may very well ask: What are their motivations? and how did they accomplish blanket taxonomic coverage in such a large field?

Their motivations are clear from the Introduction to the first paper. They believe that "many species have their true identity masked by conservative taxonomic treatment, and are experiencing extensive loss of range" and thus "an urgent task is official recognition of their existence". "Effective environmental protection can only be enhanced if a region's biological diversity is recognised at its finest possible resolution" and they argue that "lack of detailed studies is no

grounds for their widespread suppression of taxa ...". Theirs is thus a radical conservation ethic, not a desire for rational scientific enquiry. W&W believe that conservation can be enhanced by regarding every possible variant or disjunct population as a discrete species - and they set about achieving this end by stretching the International Code to the limits of absurdity.

How they achieved this end with minimum effort is simply seen. It is no coincidence that their first paper appeared soon after issue of the first volume of ABRS's Zoological Catalogue of Australia which treats Reptilia and Amphibia. This volume does all the hard work. It lists all valid species and synonyms with bibliographic references to them all; it lists type localities with location and registration numbers of type specimens; it gives distribution of all specieis. Using modern computerised word processing techniques W&W accessed what they required of this extensive database. Then they reshuffled it to not only validate hundreds of long-synonymised names but also to recombine hundreds of names under their own 90 new genera. Further, by cleverly exploiting loop holes in the Code they have put names to scores of populations mentioned in other people's publications, often without even seeing specimens or giving a diagnosis. ABRS's dream that their expensive new Zoological Catalogue series would facilitiate and expedite taxonomic research in Australia has been turned into a nightmare. The Bureau of Flora and Fauna, perhaps more than any other group, must concern itself at these events. The quality of W&W's taxonomy is unforgiveably poor, as has been documented by herpetologists King and Miller in Herp. Review 16(1): 4-5. If it is to be accepted into the herpetological literature then the whole rational contribution of the Zoological Catalogue will be negated, and the burden on conventional taxonomists to rectify the situation will be quite intolerable. Some of W&W's techniques of exploiting the Code are worth itemising, because they point to the need to tighten up the Code in some respects (See Appendix).

What of the future? W&W provide a similarly constructed "Synopsis of the Amphibia and Reptilia of New Zealand" at the rear of their 2nd Australian opus. They cite a similar synopsis of the New Guinea reptiles as "in press" and refer to a world review of reptiles and amphibia as being "in preparation". They have given notice of their intention of treating Australian fish in the same manner when the relevant Zoological Catalogue appears soon. With their obvious determination, their superficial methodology and their trusty computer these aims are probably achievable. Their task has been greatly simplified by the new 3rd Edition of the Code which permits photocopying as a valid means of taxonomic publication from the beginning of 1986. This removes any economic impediment from their activity.

Can entomology become involved? There is a very real danger that W&W's activities are about to spread to insects. It is known that W&W are attempting to establish an "alternative" periodical to be titled Australian Journal of Natural History under their Australian Biological Services umbrella. At present "Aust. J. nat. Hist." is in the same "phantom" category as Australian Herpetologist" having been cited but not sighted, e.g. by Hawkeswood in Aust. ent. Mag. 12(2): 28 as well as in W&W's second MS. Considering disputes which have occurred in areas of jewel beetle taxonomy there is a strong likelihood that Aust. J. nat. Hist. and others of W&W's publishing enterprises may provide outlets for entomological material unacceptable elsewhere.

What can be done? It is imperative that legitimate Australian herpetologists proceed with a carefully and fully documented case to the International Commission for suppression of the W&W papers. In the meantime it is extremely unwise to use any of the new nomenclature proposed by W&W. There are precedents where demonstrably mischievous publications are ignored, even in the absence of formal suppression. But unity and resolve are essential. And it is imperative that the wider biological community recognises the importance of these events, discusses them, and seeks solutions. This applies, not least, to entomologists.

APPENDIX: TECHNIQUES OF INSTANT TAXONOMY

(i) New taxa without diagnosis

Numerous new species and genera are named by W&W without presenting any diagnostic information themselves but merely refering to illustrations or statements in other publications. For instance, Covacevich (1984) described Leiolopisma jigurru sp.n based on several specimens in the Queensland Museum. She does not imply that it is discrete from all its congeners. W&W make it the type species of a new monotypic genus by the following bald statement: "Diagnosis: At present regarded as a monotypic genus confined to north-east Queensland. The description of Leiolopisma jigurru by Covacevich (1984) is adequate to diagnose the genus. Oviparous". They did not see specimens. Scores of taxa are erected in this way which is marginally legitimate because Article 13(a)(ii) allows a "bibliographic reference" to a "published statement" as diagnosis of a new name. However those names of W&W which are based solely on reference to a photograph (e.g. Lissolepis aquarius) are clearly invalid.

(ii) New taxa without seeing the type

W&W designate many holotypes from Museum collections, often citing Registration Numbers. It should not be assumed that they saw these specimens at the time of their description and

indeed it is clear that often they never sighted the specimen nominated as Holotype. For instance, Czechura (1983) records the NG monitor Varanus prasinus from Cape York on the basis of 3 specimens in the Queensland Museum and cites their Registration Numbers. W&W cite one of them as holotype of a new species, without having seen any of the three specimens. Access to Australian Museum Registration Numbers was gained during former periods of volunteer work by Wells in that institution - many are now cited as holotypes. When W&W have not been able to get precise details of potential holotypes they knew to be in certain collections they cite them in a general way, e.g. Tympanocryptis telecom; "HT - an adult specimen in the Australian National Wildlife Collection collected on Black Mountain by CSIRO staff": Tropicochelymys goodei, "HT - an adult in the Australian Museum. Collected along the Jardin River, Cape York Peninsula". The Code does not make it mandatory for an author to see or label the holotypes he designates.

(iii) Holotypes in Private Collections

W&W lodge a number of their holotypes in their private collection under the title, "Australian Zoological Museum". The Code only recommends that types be lodged in offical museums.

(iv) Lectotype Designations

Lectotype designation is a critical nomenclatural action governed by the Code which requires that a particular specimen be specified. W&W designate more than 100 in Museums around the world. It is clear that W&W have not examined syntypic series but merely quote registration numbers selected from the Zoological Catalogue. When several identically labelled syntypes were available in an overseas Museum they nominate "the largest" specimen to conceal the fact that they have not been directly examined. The Authors have not attempted to label the designated Lectotypes, in contravention of Code recommendations.

(v) Status changes without justification

W&W raise more than 300 names to species rank from synonymy or from subspecies rank. Though ethical practice demands justification of such acts W&W carry them out by mere proclamation, e.g. "We herein resurrect from synonymy ...". Such wholesale superficial procedure would not be tolerated in conventional periodicals, but is not per se, prevented by the Code.

(vi) Nomenclatural triviality and fickleness

The personal polemics of the authors are incorporated into the names of many of their new taxa (Licentia - "freedom to do as one pleases"; Phthanodon - "to anticipate or do first"; Cotundo - "to crush"; Anepischetos - "unrestrained"; Libertadictus - "devoted to freedom"; Solvonemesis - "to set free the goddess of retributive justice"). Their fickleness is shown by the fact that their 2nd "revision", appearing only 1 year after their 1st, describes 38 extra reptile genera. At least 5 genera synonymised in their 1st paper are raised again in the 2nd. Only stringent editorial standards can protect taxonomy from such irrational behaviour - the Code provides no defence.

*FOOTNOTE: On 16.09.85, after this article was originally published, T.J. Hawkeswood distributed several copies of a properly printed version of this MS in Brisbane on behalf of Wells and Wellington. The text is essential unchanged and still includes the 500 spurious literature citations. Though first revealed in September it is erroneously dated March 1. This mischievous MS is now unequivocally "published" under the Code (G.B. Monteith).

G.B. Monteith, News Bulletin Editor

IN BRIEF

CALLING ALL CLADOCEROLOGISTS!

The recent meeting of cladocerologists (SYMCLA, Budapest Aug. 12-16) resolved to produce a newsletter for global dissemination to help sort out problems of systematics and ecology, exchange methods/data, etc, and organizers seek information on interest from each continent. ASL Members who may be interested/wish to be included on mailing list should contact

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NEWSLETTER

"Rotifer News", a comprehensive newsletter and bibliography presently running to 40+ pp. is produced quarterly by:

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LIMNOLOGY BIBLIOGRAPHY

The bibliography - A plea from Russell Tait! The relatively long entry in this issue is NOT because large numbers of entries are arriving on Russell's desk. Material for 2 editions has been combined. If you have any references to be included, forward titles, abstracts, reprints or citations to:

Russell Tait
Esso Australia Ltd
GPO box 4047
SYDNEY NSW 2001

IDEAS FOR YOUR NEXT EXAM PAPER?

This is Question One from an examination paper set by a Professor Grant of London in 1860:

"By what special structures are bats enabled to fly through the air? and how do the galeopitheci, the ptermys, the petaurus and petauristae support themselves in that light element? Compare the structure of the wing of the bat with that of the bird, and with that of the pterodactyl; and explain the structure by which a cobra expands its neck, and the saurian dragon flies through the atmosphere. By what structures do serpents spring from the ground, and fishes and cephalopods leap on deck from waters? And who do flying-fishes support themselves in air? Explain the origin, the nature, the mode of construction, and the uses of the fibrous parachutes of arachnidians and larvae, and the cocoons which envelop the young; and describe the skeletal elements which support, and the muscles which move the mesoptera and the metaptera of insects. Describe the structure, the attachments, and the principle varieties of form of the legs of insects; and compare them with the hollow articulated limbs of nereides, and the tubular feet of lumbrici..." (Quoted in The Art of the Soluble by Sir Peter Medawar).

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ASL FUN RUN

The inaugural ASL Fun Run was held over a 6km course during the 24th Congress. The run commenced at some ungodly hour on the morning of Sunday August 25th. Twelve runners, mostly hung over from the dinner the previous evening, took part. Their times are listed below:

1.	Gary Morgan	30.06
	Peter Breen	30.06
2.	John Blyth	30.55
3.	Paul Harvey	31.51
4.	Tim Moulton	32.02
	Janet Dunbabin	32.02
5.	Jenny Davis	32.21
	Roy Swain	32.21
6.	Ian Campbell	37.20
7.	Jim Kyle	40.54
8.	Rhonda Sinclair	49.02

Bill Williams - set record for 2km, time not recorded but undoubtedly very fast!

Jane Chambers - did not run but managed to get out of bed in 47.26, a personal best.

Stuart Bunn - still in bed at time of printing - and still well short of his personal best.

A FUTURE FOR THE FRITSCH COLLECTION?

Professor F.E. Fritsch (Professor of Botany at Queen Mary College, London and a founder and Chairman of the FBA from 1929-1954) bequeathed his personal reference collection of algal illustrations to Dr J.W.G. Lund at the Freshwater Biological Association. The Collection, which now contains about 1/2 a million entries relating to algae from all over the world, has been microfilmed and microfiche copies are available from the Inter Documentation Company. The Collection also receives many visitors and wirtten enquiries.

In current climate of reduced support for scientific, it appears probable that the FBA will be unable to continue funding a Curator for the Collection from its Natural Environment Research Council income. This means that the Collection could not be added to or maintained, nor could the enquiry service continue.

The FBA is seeking donations to establish an investment account to provide for the continued work of the Fritsch Collection - Enquiries to

The Curator
Freshwater Biological Association
The Ferry House
Ambleside CUMBRIA LA22 OLP
UK

PRESIDENTIAL ADDRESS

Annual General Meeting, Australian Society for Limnology, Jarrahdale, WA 25 August 1985

OPTICAL WATER QUALITY - WHAT DOES IT MEAN AND HOW SHOULD WE MEASURE IT?

John T.O. Kirk (CSIRO, Division of Plant Industry, Canberra)

What constitutes "quality" can be very hard to define. Those of you who have read Robert Pirsig's partly autobiographical book - 'Zen and the Art of Motor Cycle Maintenance' - will recall that when he was a university teacher whose job it was to instruct students in the art of writing, one day someone in passing told him to make sure he taught the students "quality". This chance comment lodged in his mind and set him off in pursuit of the meaning of "quality". What is it? How do we recognise it? To find the answer to these questions eventually became an obsession with him. He gave up his job and enrolled in a Philosophy course at the University of Chicago, and continued his search, especially in the writings of the Greek Philosophers. This self-imposed task came increasingly to dominate his mind, so much so that he lost interest in everything else, and eventually went quite mad, a condition from which he was only rescued by drastic shock therapy.

Our task - that of giving meaning to the different aspects of water quality - is, however, more clearcut than the task which Pirsig set himself, since we can define the quality of water in terms of its suitability for specific uses. This is not easy, especially since we very often do not know how a change in a particular property of the water will affect its suitability for particular uses we have in mind, but should not prove so difficult as to deprive us of our sanity.

I confine my attention today to my own area of competence - namely, optical water quality. Let me first give you a general definition of optical water quality, and then I will get down to specifics. By "optical water quality" I mean the extent to which the suitability of water for its functional role in the biosphere or the human environment is determined by its optical properties. I propose in fact now to address only part of the area covered by that definition, my specific concern in this talk being with the water that is released into our inland water bodies after having been used by some form of industry - manufacturing, agricultural or mining. I do not here consider the quality of the water that comes out of our taps.

It is now generally recognised in our society, even if the necessary legislation has not always been drafted, that effluents discharged to surface water should conform to certain quality criteria, i.e. that the effluents should not lower the quality of the receiving waters to a significant extent. In the optical field, however, the criteria are by no means well defined; there is no general agreement even on what optical properties should be measured, let alone on what the actual values of the parameters, should be. And so the question I want to address is - what kind of optical quality criteria should we apply, i.e. in terms of which optical properties of the waters should optical quality criteria be framed? I shall not be proposing particular numerical values of these optical properties to which effluents should conform.

Before answering these questions we must first ask ourselves - why is the optical quality of surface water important? Once we have a good idea of why it is important we will be in a better position to decide which specific optical properties are the most relevant. Optical water quality is important because through their effects on penetration of the solar flux, the optical properties control the amount of light available for photosynthesis by aquatic plants, and for visibility for the aquatic fauna, and through their effects on water heating and stratification greatly influence the hydrodynamic behaviour of water bodies. In addition the aesthetic appeal of water bodies, whether they appear clear blue-green or opaque muddy brown, and their recreational value, are both greatly affected by the optical properties of the water.

Before going on to consider which optical properties have the greatest influence on penetration of solar radiation, and visual appearance etc., it is useful to recall the distinction, originally suggested by Preisendorfer (1961), between the inherent and the apparent optical properties of natural waters. The inherent properties are those which belong to the water (including its dissolved and suspended constituents) itself, regardless of where it is or what the nature of the ambient radiation field is: the inherent properties can therefore be measured in the laboratory. Of the inherent optical properties, the most important for our purposes are the absorption coefficient ($\underline{a}$, units m^{-1}) - for this we need a whole series of values extending across the solar spectrum; and the scattering coefficient ($\underline{b}$, units m^{-1}). The apparent optical properties are strictly speaking properties of the light field rather than of the water. The ones most relevant in the present context are $\underline{K}_d$ (units m^{-1}), the vertical attenuation coefficient for downward irradiance (in effect, the rate of change of the logarithm of downward solar irradiance with depth), and $\underline{R(0)}$, the irradiance reflectance (ratio of upward to downward irradiance) just below the water surface. Although $\underline{K}_d$ and $\underline{R(0)}$ are actually properties of the underwater light field, their values for any given water body are largely determined by the inherent optical properties ($\underline{a}$ and $\underline{b}$) of the particular water, and are not very sensitive

George Ganf proposing to (or was it propositioning?) Margaret Hart.

Lunch. Back row - Moe De Haan, Tom Rose, Dave Macey. Middle row - Marlin Atkinson, Shannon Atkinson, (evidently photographed while having an interesting experience with a bull ant or Dave's shoe - or both), Jenny Davis, Peter Liehne. Front row - Paul Harvey, Janet Dunbabin, Phil Sinclair.

John Kirk delivering his paper on the optical properties of ball point pens.

Following last year's effort by Bayly and Ganf, Jorg Imberger attempts to prove that hydrodynamicists are cleverer than biologists because they can count their fingers even with their eyes closed. However, as this picture proves, he actually peeped through his left eye.

Linda Moore, Dept of Microbiology, UWA having difficulty pronouncing stromatolithologist.

Prof Noel Hynes attempting to enliven his Jolly Award address by having the clap in time.

Steven Rolls - T Shirt Sales Persons.

Peter Breen, John Blyth, Tim Moulton, Paul Harvey, Gary Morgan, Jenny Davis, Jim Kyle, Roy Swain, Ian Campbell.

Michele Barson is highly impressed by John Blyth's purple 1970s suit - a pity we couldn't print this one in colour. The hands are reputed to belong to Tony Friend.

Dr Bayly's reaction to the suggestion by Prof Williams that they should produce a new edition of "the book".

The Conference organising team on the last night. Back row - Jane Chambers, Jenny Davis, Guy Watson, Stuart Bunn, Margaret Brock (what was she doing to Stuart?), Don Edwards. Front row - Faye Christofis (is she a member?), Steven Rolls, Dave Macey, Ian (Pig) Dadoun.

The 1985-86 Executive. Back row - Mark Harvey, Mike Geddes, Jenny Davis, Richard Marchant (Secretary) Kath Bowmer, Cathy Yule (Precipitation impressionist extraordinaire), Roe St. Clair, John Kirk. Front row - Ian Campbell (President), Michele Burston (Newsletter Editor), Peter Breen. (Absent, Meagan Hart (drunk) and Terry Hillman, Vice President - had more sense!).

to changes (caused for example by variation in solar altitude or cloud cover) in the incident solar flux. These 'apparent' optical properties can therefore as a rough but useful approximation be attributed to the water body itself, and their values will not change very much regardless of the time of day or the weather conditions, for as long as the composition of the water remains unchanged. It must be remembered that K_d and $R(0)$ are always measured for some specified spectral waveband. This might be a narrow waveband centred on wavelength λ (in which case we refer, for example, to $K_d(\lambda)$), or, very commonly the whole 400-700 nm waveband of photosynthetically available radiation (in which case we would refer to $K_d(PAR)$). I give a detailed account of these and other inherent and apparent optical properties of natural waters elsewhere (Kirk, 1983).

Of the optical properties referred to above, the ones which are of the most immediate relevance for an understanding of the penetration of solar radiation into, and the visual appearance of, water bodies are K_d and $R(0)$, since they describe, respectively, the rate of attenuation of the solar flux with depth, and the proportion of the incident light which is redirected back towards an observer. Although K_d and $R(0)$ are largely determined by the inherent properties, a and b, we may not need to know a and b if the two apparent optical properties provide all the information we need. So why then, you may ask, should we not in most cases confine ourselves to measuring just K_d and $R(0)$? The reason why is that these are properties of the water body, not of a water sample, and the industrial water user needs to know the optical effects of his effluent before it is ever discharged to the receiving water body.

So here we have a dilemma. We need to know the effects of an effluent on K_d and $R(0)$ but we can only directly measure this after the effluent has been discharged into the water body. There are two possible solutions. The first is for the water user to measure the inherent optical properties of the effluent in the laboratory, and then calculate, by a procedure I shall briefly describe, what effect the effluent will have on the apparent optical properties of the water body when mixed in with it. The second is for the water user to construct a water tank large enough, when filled with his effluent, or appropriate effluent/receiving water mixtures, for *in situ* measurements of K_d and $R(0)$ to be made which will be acceptably close to the values they would have in the water body itself. I shall consider each of these possibilities in turn.

If the water user chooses the option of calculating the $K_d(PAR)$ and $R(0)$ values from the inherent optical properties, then he must measure the scattering coefficient, and a set of values for the absorption coefficient across the 400-700 nm range, of the effluent. The scattering coefficient is easily determined, since he can take advantage of the fortunate

coincidence (Kirk, 1983) that the nephelometric turbidity in NTU has approximately the same value as the scattering coefficient in m^{-1}. The absorption coefficients are not so easily determined, since it is essential that as well as the spectrum of dissolved material, the contribution of the particulate matter must be determined and this requires the use of a spectrophotometer adapted for measurements on scattering samples. Although such instruments are not yet routinely found in industrial laboratories, nevertheless the technology does exist and the methodology has been described (Kirk, 1980), and there is no reason why industries wishing to discharge wastes into surface waters should be excused from the requirement of adequately characterising them first.

Having determined the inherent optical properties of the effluent, the next step is to carry out the same measurements on the receiving water. Then from the anticipated dilution rate of effluent in the receiving water, the scattering coefficient and a spectral set of absorption coefficients in the final mixture can readily be calculated.

The final stage is to proceed from the measured set of inherent optical properties of the water to the resultant apparent optical properties of the water body. This can be achieved by taking advantage of certain empirical relationships between inherent and apparent optical properties, derived by computer simulation (Kirk, 1981, 1984a). The relationship for $\underline{K}_d$ is

$$K_d(av) = \frac{1}{\mu_o} \cdot [a^2 + (0.425 - 0.190)ab]^{\frac{1}{2}} \qquad (1)$$

and for R(O) is

$$R(O) = (0.975 - 0.629\mu_o)b_b/a \qquad (2)$$

where $\underline{K}_d(av)$ is the average value of $\underline{K}_d$ for monochromatic light of some specified wavelength through the euphotic zone (that layer in which 99% of the downward irradiance is removed), μ_o is the cosine of the angle of the photons in the direct solar beam to the vertical just below the surface, and $\underline{b}_b$ is the backscattering coefficient (that part of the total scattering coefficient which corresponds to scattering in a backwards direction; $\underline{b}_b = 0.019\ \underline{b}$ in most natural waters).

It will be noted that these relationships apply to monochromatic light, whereas we are usually more interested in the whole visible/photosynthetic solar waveband. To obtain values of the apparent optical properties for such a broad waveband, a standard incident solar spectral distribution is assumed, the calculation is carried out for each of a series of narrow wavebands using the appropriate value of absorption coefficients and the scattering coefficient determined as already described, and then by summing across the whole waveband the value of, say, $\underline{K}_d(PAR)$ is obtained. In the age

of the ubiquitous microcomputer such a calculation is not as tedious as it sounds, and I describe elsewhere (Kirk, 1984b) a simple and quick procedure for achieving this.

The essential point, then, is that once we have determined from laboratory measurements the inherent optical properties of the effluent and of the receiving water, we can calculate for standardised climatic conditions the vertical attenuation coefficient and the reflectance in the visible/photsynthetic waveband for the water body with and without effluent, and in this way determine how much effect the effluent will have on the optical characteristics of the water body. But if you feel moved to ask - why isn't industry doing this already? - then in fairness it must be pointed out that the theoretical relationships required in order to carry out such calculations have only recently been arrived at, and the spectrophotometric techniques are not much older. Nevertheless they are all available now, and it is to be hoped that industries discharging effluent to surface waters will begin to make use of them.

The second approach is conceptually simpler. It involves the water user constructing a pilot-scale model of a water body, filling it with the effluent, and with various mixtures of effluent and the receiving water, and directly measuring the vertical attenuation and reflectance of the solar flux. Unfortunately I am not yet in a position to specify what the minimum dimensions of such a model water body should be in order to yield values of $K_d(PAR)$ and $R(O)$ which would be acceptably close to those of typical real water bodies. My provisional off-the-cuff judgement is that a tank not less than about 3 m wide by 3 m deep, capacity *ca* 23 000 litres, would be the minimum, and even this might work satisfactorily only at a high solar altitudes. Part of the problem is the shadow cast by the side of the tank facing the sun. Also, much of the light received by an underwater irradiance meter originates in scattering from laterally distant parts of the water body, and part of this light flux will inevitably be lacking in a tank only a few metres across.

A problem with this approach is that while the inherent optical properties of the effluent and the receiving waters, i.e. the a and b values, can each be combined additively in order to carry out calculations for various possible mixtures, the assumption of additivity of the vertical attenuation coefficients is only approximate. Thus, an effluent with a = 10.0 diluted 10-fold into a receiving water with a = 1.0 will give a final absorption coefficient value of 2.0. However, an effluent, which on its own gives a $K_d(PAR)$ of 10.0, on dilution 10-fold into a receiving water for which $K_d(PAR)$ is 1.0, will give a final $K_d(PAR)$ which is not exactly equal to 2.0. Measurements will need to be carried out on effluent-receiving water mixtures similar in composition to those anticipated in practice.

Whether the optical consequences of effluent discharge are estimated on the basis of measurements in the laboratory or in pilot-scale outdoor water bodies, attention will have to be paid to the possibility that the optical properties of the effluent might change as a consequence of interaction (other than, of course, merely by dilution) with the receiving water. If, for example, electrolytes in the receiving water caused rapid aggregation of suspended particles in the effluent, then the optical properties of the mixture would not be calculable on the basis of the mixing proportions alone, the appropriate measurements would have to be carried out after mixing and interaction had taken place.

I have confined my attention in the foregoing to the effects of effluent discharge on the vertical attenuation and the reflectance of the solar flux. There remains, however, one further optical property of the water body which is important not only for those members of the underwater fauna which seek their food by visual means, but also to people using the water for recreational purposes, namely, visual clarity. This is normally measured in terms of the Secchi disc depth, $\underline{z}_{SD}$, but this too, like $\underline{K}_d(PAR)$ and $\underline{R}(0)$ is an apparent optical property which can only be directly measured in a substantial body of water, and so it is not obvious how an industrial concern wishing to discharge effluent to a surface water is to determine it directly even in a large concrete tank if the Secchi depth exceeds the depth of the tank. A possible solution is to take advantage of the fact that on theoretical grounds it has been shown (Tyler, 1968) that the reciprocal of the Secchi depth is approximately proportional to the sum of the beam attenuation coefficient, $\underline{c}$ (which is the sum of $\underline{a}$ and $\underline{b}$), and the vertical attenuation coefficient for downward irradiance, $\underline{K}_d$ (in that waveband to which the human eye is most sensitive, i.e. 400 to 700 nm, but with greatest sensitivity at about 550 nm). It turns out that the reciprocal of the Secchi depth is approximately equal to $\underline{(c + K_d)/q}$ (Tyler, 1968, Holmes, 1970). I have presented eleswhere (Kirk 1982, 1985) reasons for treating $\underline{(c + K_d)}$ as an apparent optical property in its own right, which may be referred to as the vertical contrast attenuation coefficient, and given the symbol - $\underline{K}_c$. The significance of $\underline{K}_c$ in the present context is that its value can be derived from the values of absorption and scattering coefficients measured in the laboratory. The value of the beam attenuation coefficient, $\underline{c}$ is equal to the sum of the measured values of $\underline{a}$ and $\underline{b}$ at the wavelength in question, and $\underline{K}_d$ can be calculated from these same values of $\underline{a}$ and $\underline{b}$, using equation (1), assuming (in order to fix the value of μ_o) some standard solar altitude, e.g. 45°.

The wavelength for which we obtain the value of $\underline{a}$ must of course be specified. I suggest that an appropriate wavelength would be 550 nm, not only because it is the centre of the visible/photosynthetic waveband, but also because it is to this yellowish-green light that the human eye is most sensitive.

Thus our standardised vertical contrast attenuation coefficient could be defined by

$$K_c\ (550\ nm) = a(550\ nm) + b + K_d\ (550\ nm, 45^o) \qquad (3)$$

The value of b, fortunately, varies little with wavelength and so it is not necessary to specify at what wavelength it should be measured.

We have now arrived at three different optical properties in terms of which optical water quality can be characterised.

* the vertical attenuation coefficient of PAR, $K_d(PAR)$, which is a measure of the ability of the water to attenuate solar radiation.

* the reflectance of the water body for PAR, R(0, PAR), which provides information about the appearance of the water body to an external observer.

* the vertical contrast attenuation coefficient (at 550 nm), K_c (550 nm), which is an inverse measure of the visual clarity of the water.

In addition we hve seen how the effects of waste water discharge on these properties in a water body can be estimated on the basis of measurements made on the effluent before it is released into the receiving water. What this means is that we now have the conceptual framework to set quantitative optical water quality standards. Thus, where an industrial concern wishes to discharge waste water to a surface water body, the relevant state department could say that the effluent must not increase the vertical attenuation coefficient for PAR by more than x%, the reflectance of PAR by more than y%, and the vertical contrast attenuation coefficient by more than z%. Just what would constitute appropriate values for x, y and z, I shall not attempt to say, except that they should certainly be very small. Part of the problem is that such values are likely to be site-specific. For example, since effects would be cumulative, standards where there are several industries close together all discharging into the same water body might have to be much more stringent than in the case of an isolated source of effluent.

So, what I have tried to put together here - for the benefit both of industrial water users and of the relevant state departments - is not a ready-made, off-the-shelf set of optical water quality standards, but rather suggestions first for a minimum set of three water optical properties that should be determined; second, how these could be measured; and third in what sort of terms standards of waste water optical quality could then be framed. I hope these ideas may prove to be of some use.

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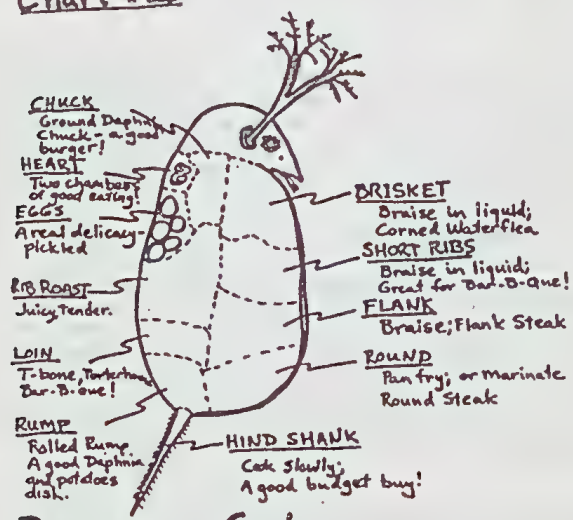
AQUATIC HUMOROLOGY

Chart #23



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COMING EVENTS

15 NOVEMBER
Eighth Annual Meeting of the British Simuliid Group. Talks, discussions and exhibits. Details from: Dr R.J. Post, Department of Medical Entomology, Liverpool School of Tropical Medicine, Pembroke Place, Liverpool L3 5QA (also venue for meeting).

18-21 NOVEMBER
National Strategies for Managing Hazardous Waste, Melbourne. Contact: HAZCHEM Conference Secretariat, c/- MMBW, Industrial Waste Division, 625 Little Collins St, Melbourne 3000.

19-20 NOVEMBER
Recycled Water - Marketing a Valuable Resource Bendigo, Vic. Contact: Recycled Water Seminar, Department of Water Resources, 590 Orrong Road, Armadale Vic 3143.

2-6 DECEMBER
Polmet '85 ASPAC regional conference: pollution in urban areas, Hong Kong. Contact: The Secretariat, POLMET '85, 57 Wyndham Street, 1st Floor, Central, Hong Kong.

12-14 DECEMBER
International seminar on environmental impact assessment of water resources projects, Roorkee, India. Contact: Dr V.C. Chaube, Water Resources Development Training Centre, University of Roorkee, Roorkee - 247667 (UP), INDIA

24-27 MARCH
Freshwater Wetlands and Wildlife Symposium, Charleston, South Carolina USA. Contact: Dr R. Sharitz, Savannah River Ecology Laboratory, Drawer "E", Aiken, South Carolina, 29802 USA.

27 APRIL - 3 MAY
Respiration and its effects on the measurement of aquatic primary productivity, Durban, South Africa. 3rd Int. Workshop of Group for Aquatic Primary Productivity. Contact: Dr R. Roberts, GAP, c/- Symposium Secretariat S371, CSIR, PO Box 395 Pretoria 0001 South Africa.

3-6 JUNE
Pro Aqua-Pro Vita - covers all environmental and pollution control techniques, Basle, Switzerland. Contact: Swiss Industries Fair, Pro Aqua-Pro Vita 86, PO Box, CH-4021 Basle, Switzerland.

22-29 JUNE
Nineteenth International Ornithological Congress. Ottawa, Canada. Details from: Dr Henri Ouellet, 19th Congressus Internationalis Ornithologicus, National Museum of Natural Sciences, Ottawa, Ontario, Canada KIA OM8.

22 JUNE - 9 JULY
Second International Symposium on Indo-Pacific Marine Biology. Venue: University of Guam. Details: Prof. D.H. Montgomery, Biological Sciences, Cal Poly State University San Luis Obispo, California, USA, 93407.

15-16 JULY
Fifth conference on science and technology, Sydney, NSW Contact: Mr S. McKay, Secretary ANZAAS-AIST Conference, School of Biological Sciences, Macquarie University, North Ryde, NSW 2113

20-24 JULY
Conference on research and applications of aquatic plants for water treatment and resource recovery, Orlando, Florida, USA Contact: Dr Wayne H. Smith, Chairman, Aquatic Plants Conference Steering Committee, University of Florida, IFAS, McCarty Hall, Room G040, Gainsville, FL32611 USA

4-6 AUGUST
International symposium on drainage basin sediment delivery, Albuquerque, New Mexico, USA. Contact: Professor R.F. Hadley, Department of Geography, University of Denver, Denver C.O. 80208 USA

10-16 AUGUST
IV International Congress of Ecology. Global connections in ecological theory and practice. SUNY, Syracuse, New York. Details from: IV International Congress of Ecology, SUNY College of Environmental Science and Forestry, Syracuse, NY 13210, USA.

15-19 SEPTEMBER
Seventh international symposium on aquatic weeds: The biology and control of aquatic weeds, Loughborough, Leicestershire, UK. Organised by the European Weed Research Society and the Association of Applied Biologists. Contact: Dr Max Wade, Department of Human Sciences, Loughborough University of Technology, Loughborough, Leicestershire, LE11 3 TU, UK.

25-27 NOVEMBER
Hydrology and water resources symposium 1986 "River Basin Management" Brisbane Qld Contact: The Conference Manager, Hydrology and Water Resources Symposium 1986, The Institution of Engineers, Australia, 11 National Circuit, Barton ACT 2600

1987

8-14 FEBRUARY
Twenty third SIL Congress, Hamilton, New Zealand, Contact: Convention Management Services, PO Box 3839, Auckland, New Zealand

18-24 FEBRUARY
Fifth international conference on Ephemeroptera, Marysville, Victoria. Contact: Dr I. Campbell, Water Studies Centre, Chisholm Institute of Technology, East Caulfield, Victoria 3145.

18-24 FEBRUARY
Ninth international conference on Plecoptera, Marysville, Victoria. Contact: Dr I. Campbell, Water Studies Centre, Chisholm Institute of Technology, East Caulfield, Victoria 3145.

24 JULY - 1 AUGUST
XIVth International Botanical Congress, Berlin, FRG. Contact: XIVth International Botanical Congress, Botanisches Museum Berlin-Dahlem, Konigin - Luise - Strasse 6-8, D-1000 Berlin 33, FRG.

17-24 AUGUST
The First International Congress of Dipterology. Venue: Budapest, Hungary. Details: Dr. Laszlo Papp, Zoological Department, Hungarian Natural History Museum, Baross u. 13., Budapest, H-1088 HUNGARY.

24-29 AUGUST
Fourth International Symposium on Microbial Ecology, Ljubljana, Yugoslavia. Contact: Prof. France Megusar, Biotechnical Faculty, E. Kardej University of Ljubljana, Jamnikdrjeva 101, 61000 Ljubljana, Yugoslavia.

25-28 AUGUST
The ecology of the Australian wet tropics - Ecological Society of Australia and Australian Systematic Botany Society symposium, Brisbane, Qld Contact: Uniquest Limited, University of Queensland, St Lucia, Qld 4067

25-29 AUGUST
Third European Congress of Entomology. Netherlands Entomological Society, Amsterdam.